Applications of Land Remote Sensing in NOAA's NWP

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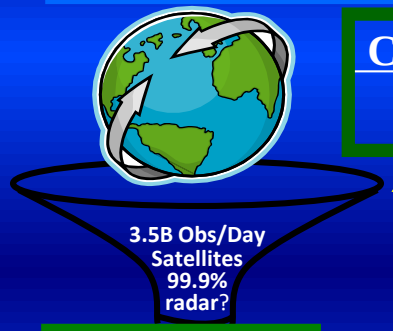
Background

- The land surface model (LSM) is an essential component of modern weather and climate forecasting systems.
- Accurate and detailed land surface information is critical for environmental modelling, risk assessment and decision making.
- The parameters used in LSMs are partly poorly constrained due to sparse land surface observations.
- Novel satellite-derived datasets can improve LSM configuration, and hence can contribute to the improvements of environmental modelling, weather predictability, risk assessment and decision.

Noah(-MP) Land Model Connections in NOAA's NWS Model Production Suite



3.5B Obs/Day
Satellites
99.9%
radar?

Global Data Assimilation

Regional Data Assimilation

Climate Forecast System (CFS)
MOM4/GFS/GLDA/Sea-Ice

GFS/ FV3GFS

Global Ensemble Forecast System (GEFS)

North American Ensemble Forecast System
GFS, Canadian Global Model

Hurricane
HWRF, HMON

2-way coupled

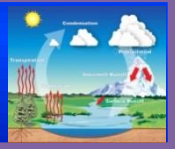
Regional NAM
NMMB

Short-Range Ensemble Forecast
WRF-ARW, NMMB

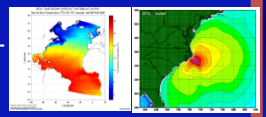
RCDAS/NARR
Eta

NLDAS
(Uncoupled)
(drought/flooding)

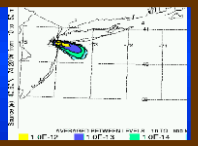
Nat. Water Model



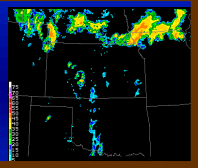
Oceans
HYCOM
WaveWatch III



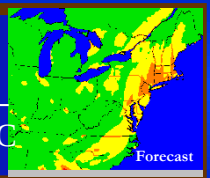
Dispersion
ARL/HYSPLIT



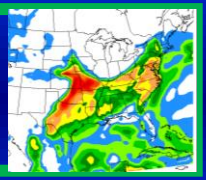
Severe Weather
HREF/HIRESW
(ARW & NMMB)



Atmospheric Composition
NMMB/CMAQ/NGAC



RAP/HRRR
(ARW-based)
/RUC LSM

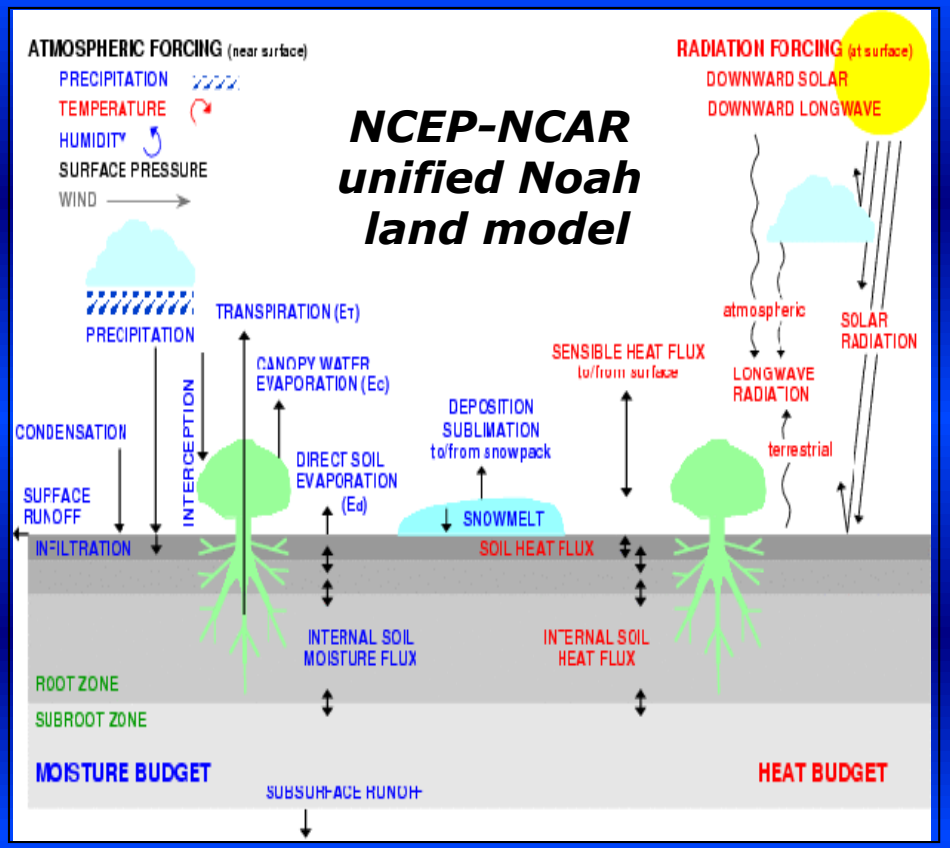


NCEP
NCAR
UT-Austin
U. Ariz.
& others

NOAH(-MP) Land Surface Model

LSM's Role and Requirements

- Close surface energy & water budgets,
- Determine **heat**, **moisture**, and **momentum** exchange between surface & atmosphere,
- Provides surface boundary conditions to parent atmospheric model, e.g. NAM, GFS, CFS, FV3GFS.



- Appropriate **physics** to represent land-surface processes,
- **Atmospheric forcing** to drive land model,
- **Initial land states**, e.g. soil moisture/ice and snow, analogous to initial atmospheric conditions, though land states may carry more "memory", especially deep soil moisture, similar to SSTs,
- **Land surface physical property data sets**, e.g. land use/land cover (vegetation type), soil type, surface albedo and emissivity, and associated parameters, e.g. surface roughness, soil and vegetation properties.

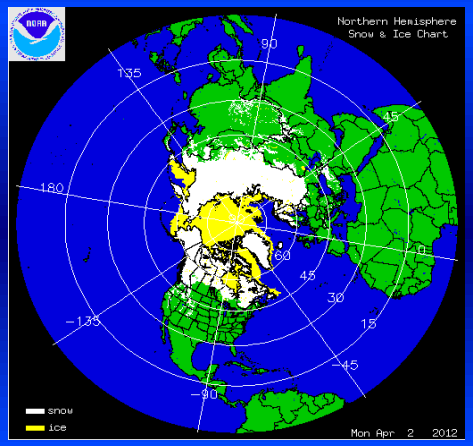
Land Surface Remote Sensing Products

- land cover change monitoring (land use type)
- Vegetation mapping and monitoring (vegetation type, cover area (GVF), plant density (LAI), plant height, plant phenology)
- Soil type (mostly relied on ground-based surveys)
- Soil moisture mapping (drought detection, flood monitoring, modeling)

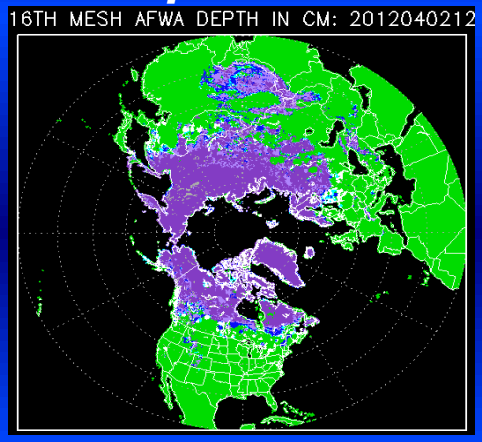
- Surface albedo and emissivity
- Snow cover and depth
- Wild fire monitoring
- Land surface temperature
- Determination of evapotranspiration
- Lake surface temperature
- Precipitation
- Urban surface physical parameters

Snow Products

Initial land states: 02 April 2012

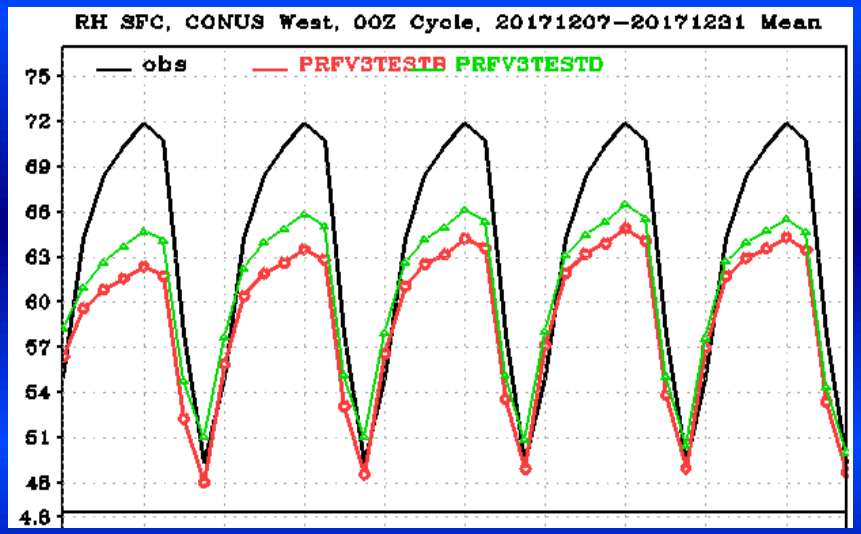


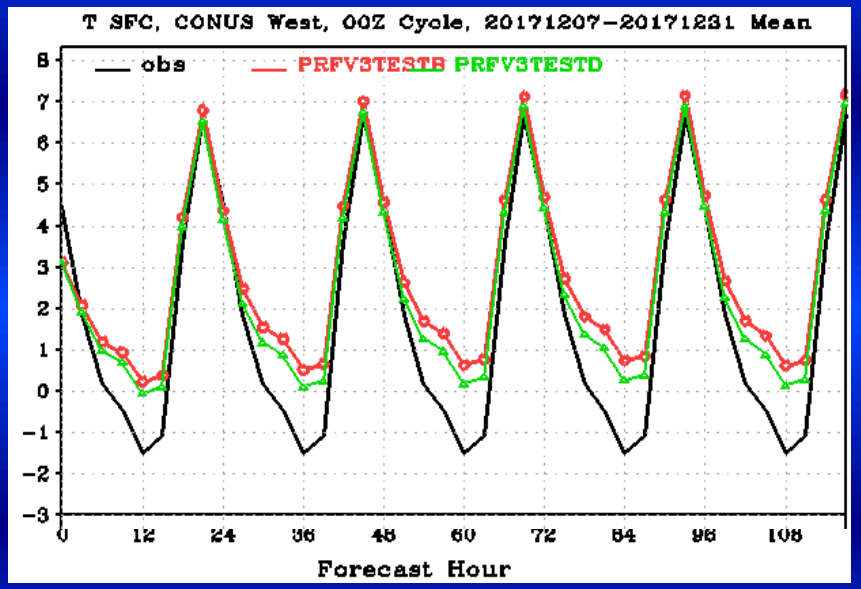
4-km Snow Cover (daily integrated NIC IMS product)

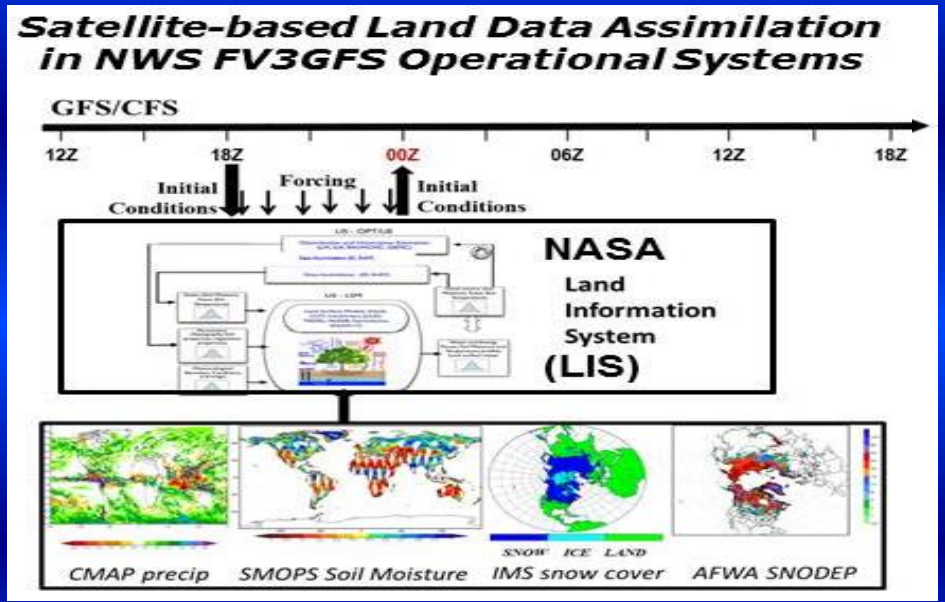


24-km Snow Depth (daily integrated AFWA product)

Snow Depth Effects in Data Assimilation

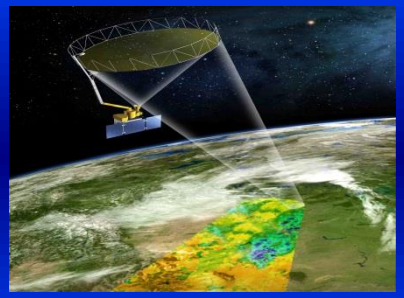




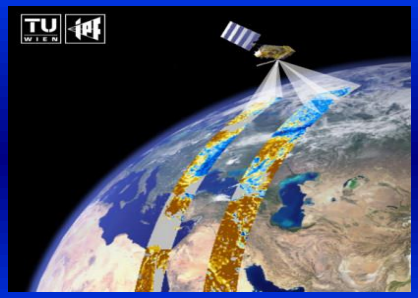


SMAP Soil Moisture

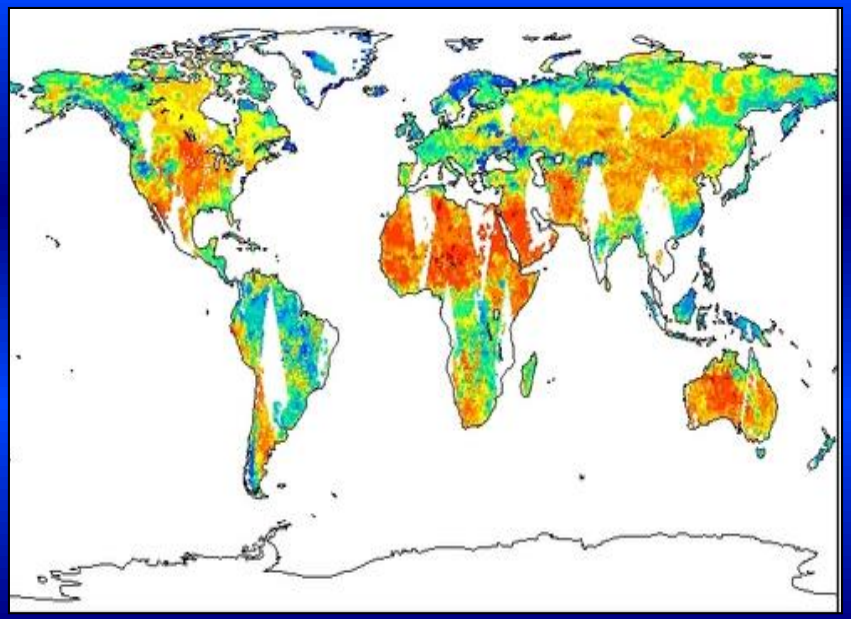
Initial land states



ESA SMOS

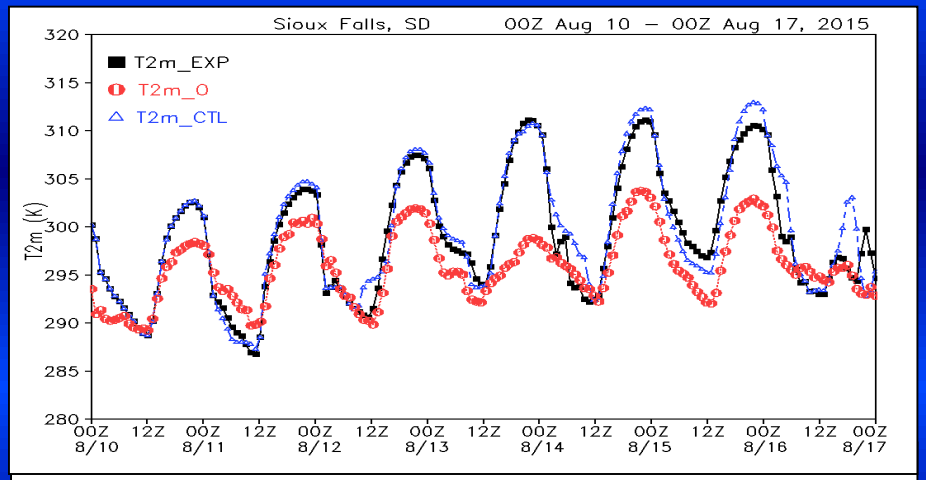


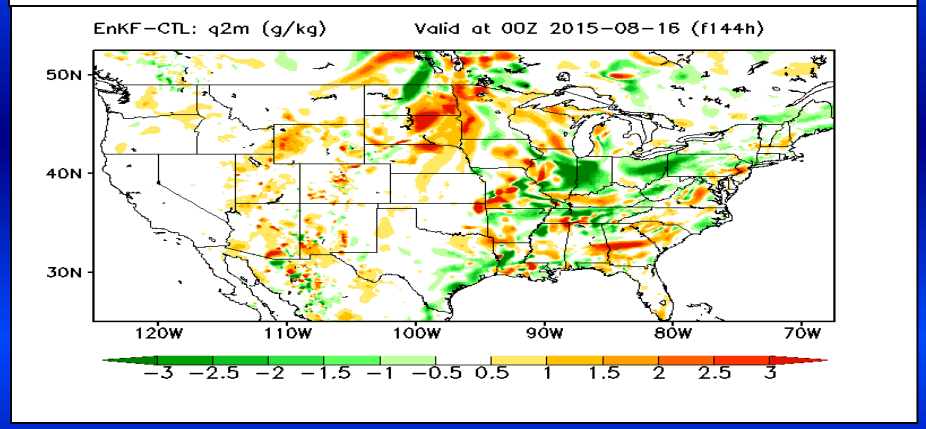
NASA SMAP
(Oct 2014 launch)



SMOPS Blended Daily Soil Moisture

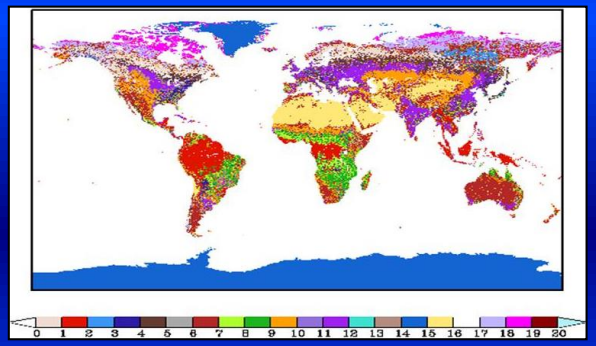
Data Assimilation



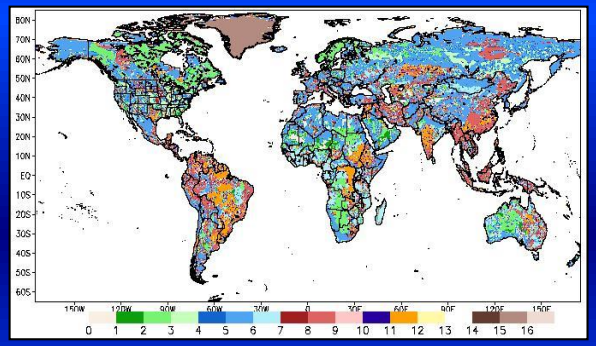


- *Assimilating SMAP SM for a case (Aug 10, 2015) can reduce some warm biase T2m forecast in the GFS;*
- *Impact of 2-meter specific humidity varies significantly spatially.*

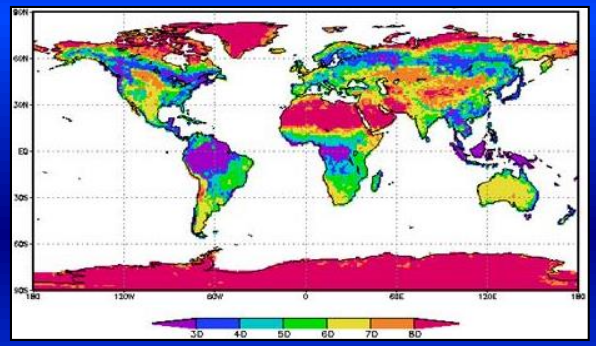
Land Data Sets *(NAM ~12/4/1-km)*



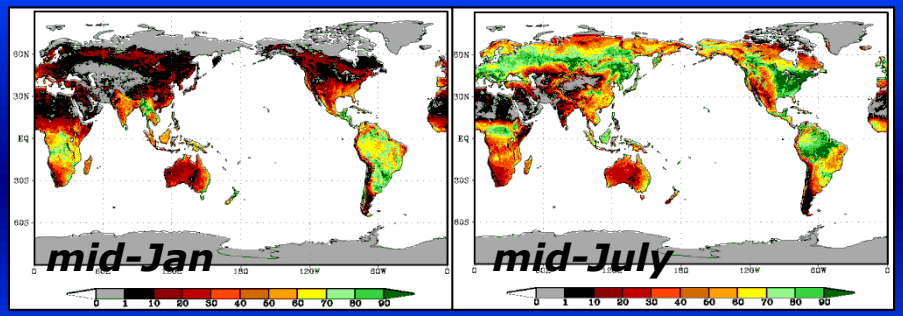
Vegetation Type
(1-km, IGBP-MODIS)



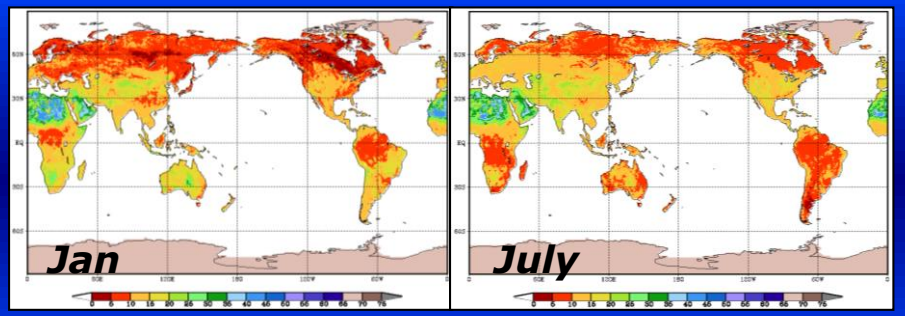
Soil Type
(1-km, STATSGO-FAO)



Max.-Snow Albedo
(1-km, UAz-MODIS)



Green Vegetation Fraction
(monthly, 1/8-deg, AVHRR)

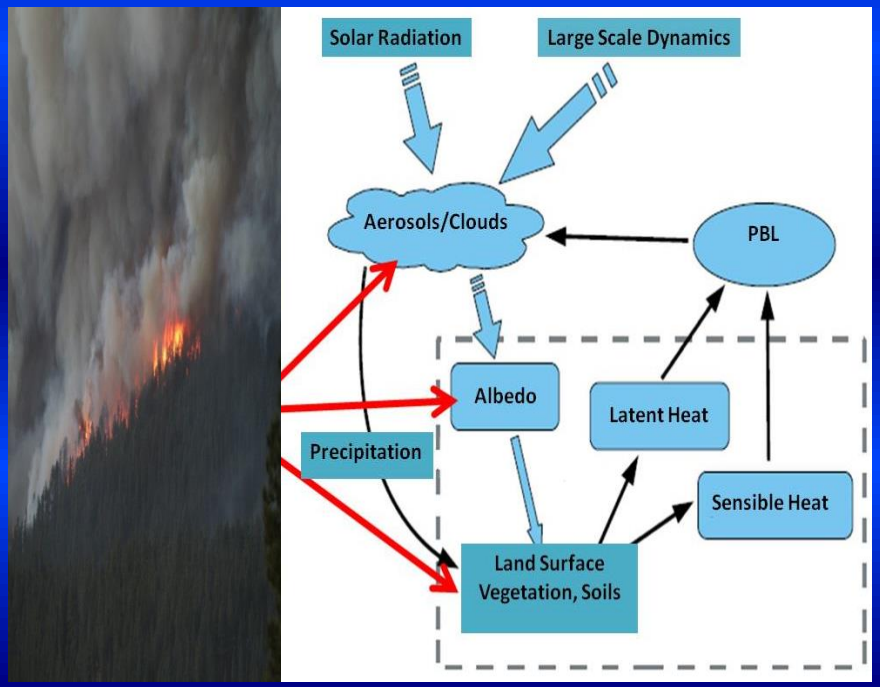


Snow-Free Albedo
(monthly, 1-km, BU-MODIS)

- Most are fixed annual/monthly/weekly climatologies.
- **Near real-time are better than fixed values.**

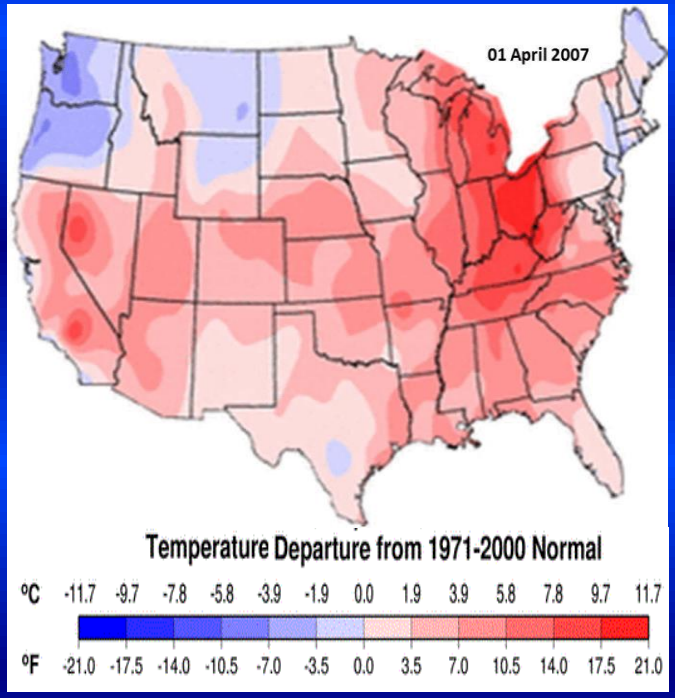
Land Conditions: Wildfire Effects

Wildfires affect weather/climate systems:
(1) atmospheric circulations
(2) aerosols and clouds
(3) **land surface states** (green vegetation fraction, albedo and surface temperature etc.) --> impact on surface energy budget, boundary-layer evolution, clouds & convection.

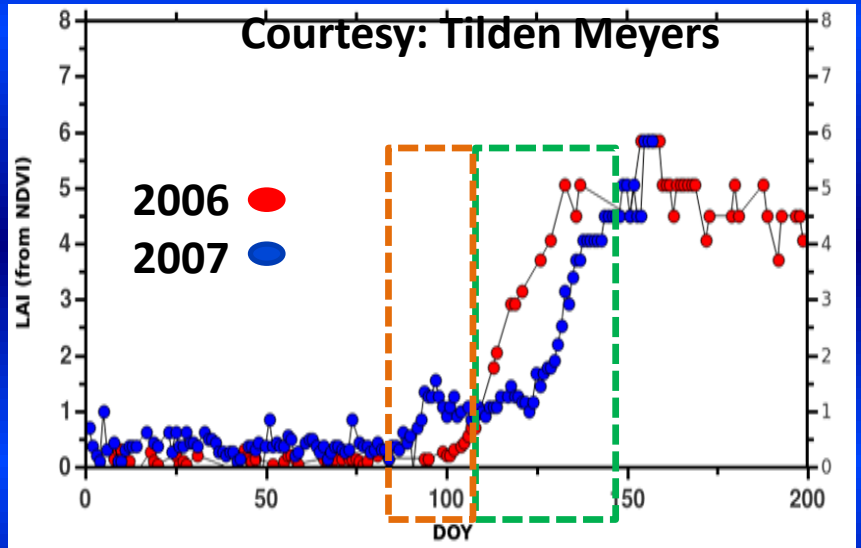


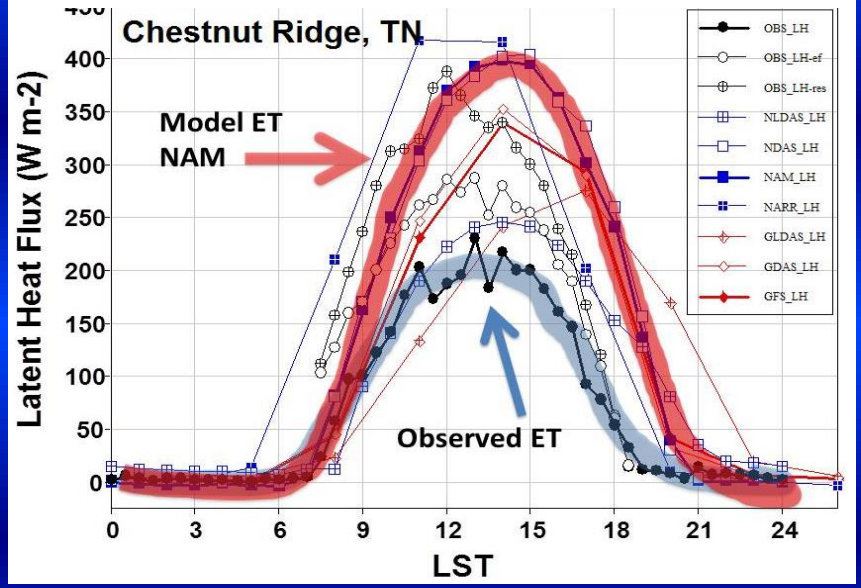
Burned Area (NESDIS/STAR): Near Real time burned area product was tested & used in operational NAM.

LAI Reduced by the Easter Freeze of April 2007

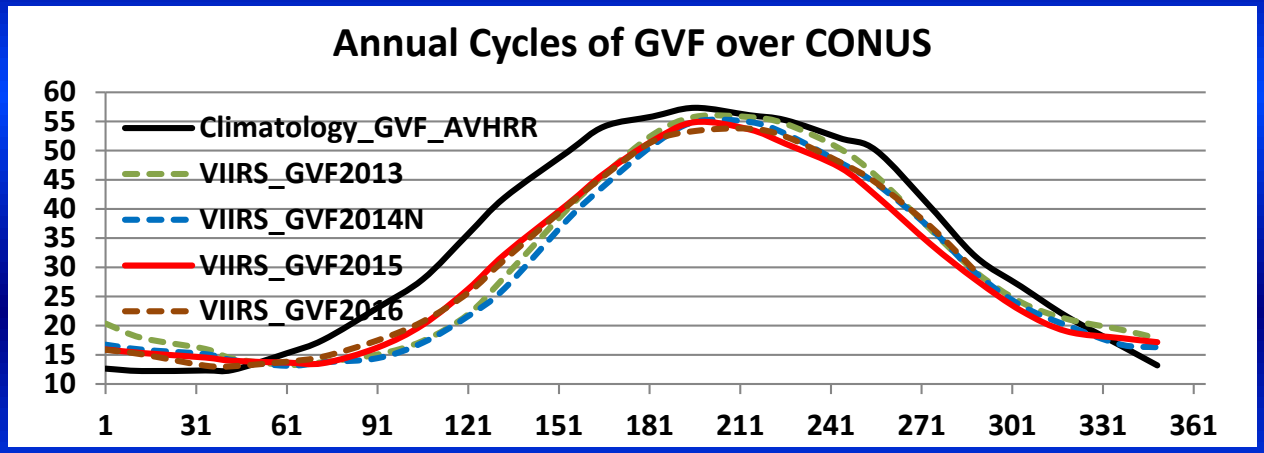


- In March 2007, unseasonably warm weather over the eastern half of the US prompted early growth of many crops.
- In early April (4-10), an Arctic cold hit the same region. Air temperatures in many locations were well below 25°F.
- The widespread freeze extensively damaged agriculture in 18 states in the region. Many farmers lost about 90% or nearly all of their crops.
- It also caused problems in NOAA weather forecast.

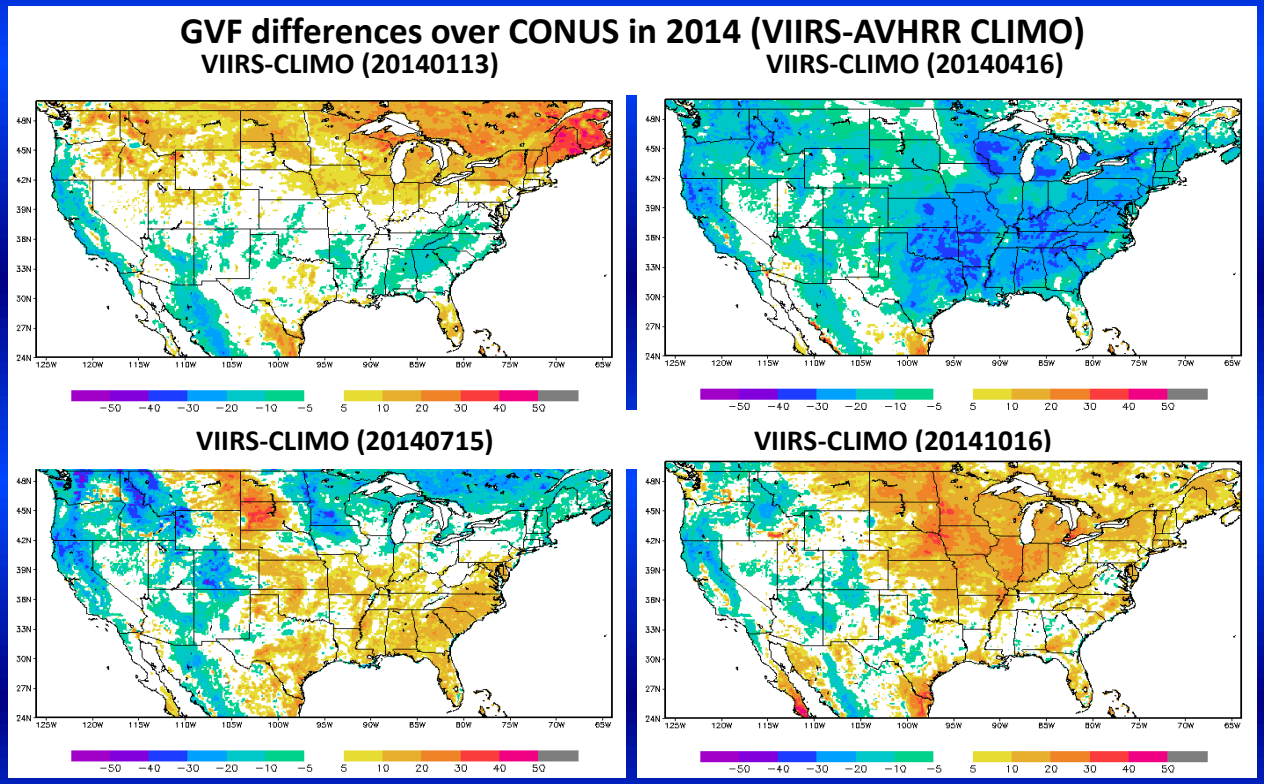




Near Realtime VIIRS GVF *vs.* AVHRR GVF Climatology



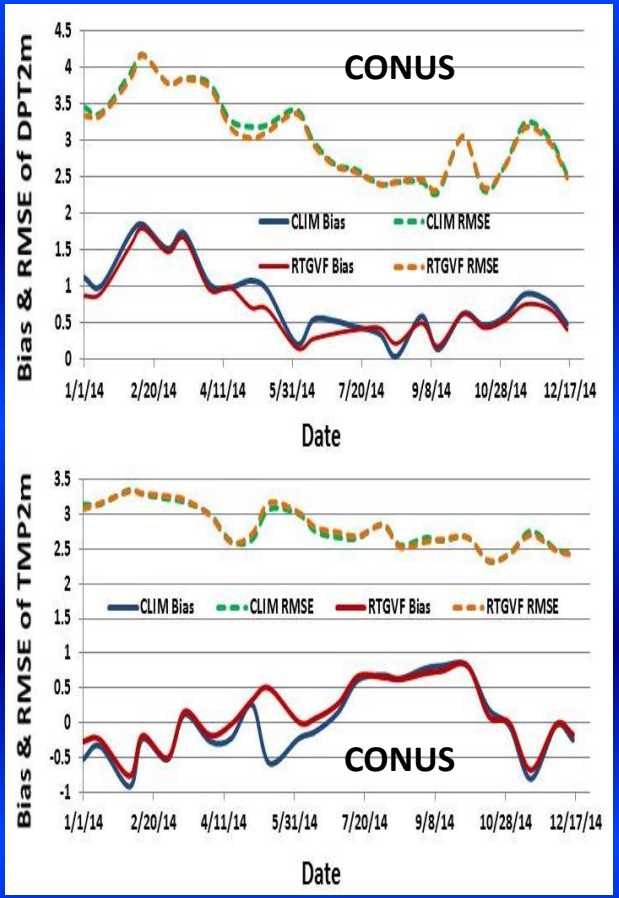
- Climatology GVF green up earlier
- Climatology GVF is higher most of a year



- VIIRS GVF is higher at high latitude in January
- VIIRS GVF is much lower over the entire USCONUS in April
- VIIRS GVF is higher in southeast US in July
- VIIRS GVF is higher over the eastern US in October

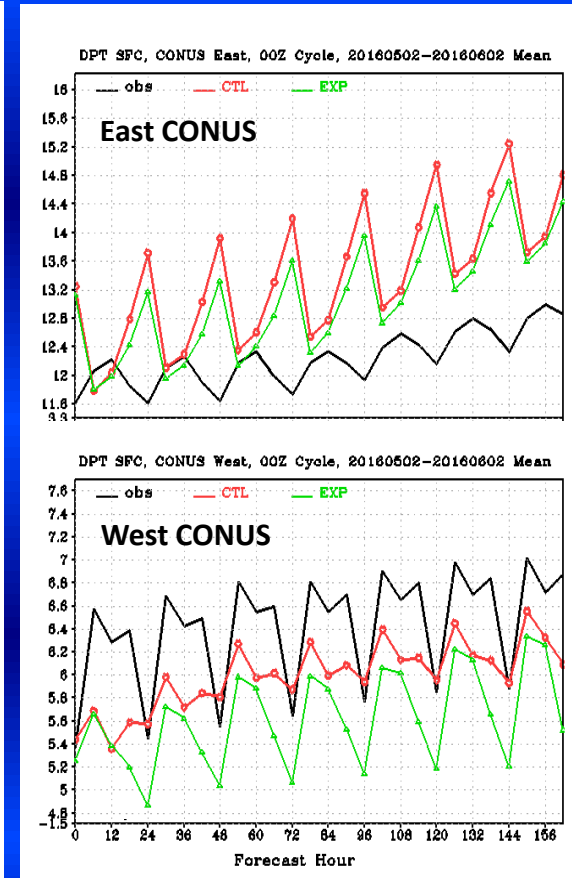
Tests of the Near-Real Time GVF in NAM and GFS

GVF Tests in NMA 2014

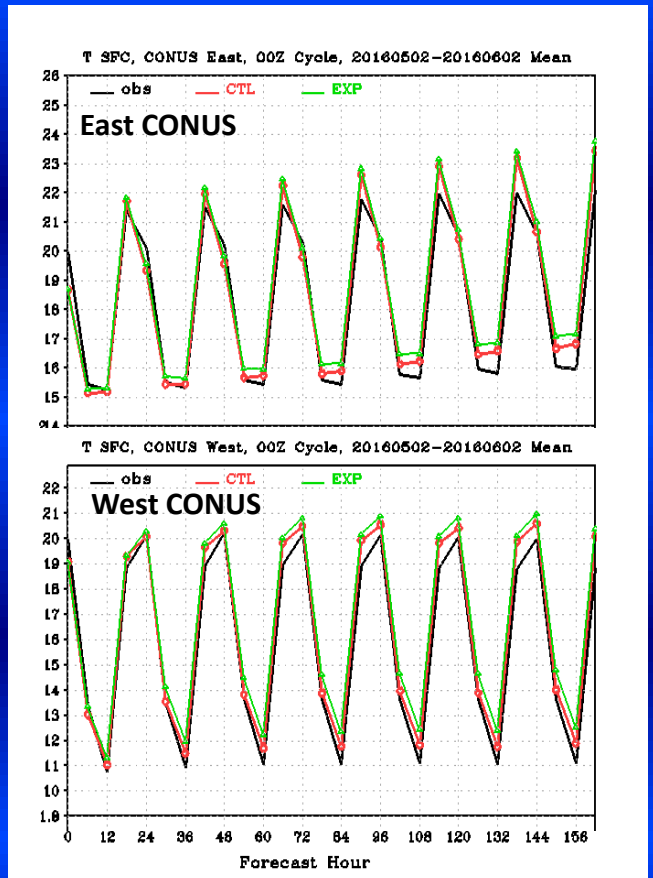


Reduce the bias of DPT2m and T2m in 2014

GVF Tests in GFS 5/02-6/02, 2016



East CONUS:
Reduce wet bias and RMSE.
West CONUS:
Increase dry bias and RMSE.



Increase warm bias and RMSE

Summary

- Real time, high spatial resolution, consistent remote sensing products can improve NWP.
- Consistency between all products, e.g. a "burned area product" also reflected in green vegetation fraction (GVF), albedo, emissivity, surface temperature, soil moisture, etc.
- Consistent use between NCEP global and regional models (global and regional FV3GFS).
- Future: account for lakes, wetlands, water bodies.
- Land data assimilation in LSM & UNLDAS will use NASA Land Information System (LIS), i.e. snow, soil moisture, GVF (Noah-MP with dynamic/growing vegetation).
- Several satellite data sets developed recently (e.g., GVF, snow, albedo, LST,) have been tested in the NCEP models. We will continue our efforts, and work together with several research teams including NESDIS to improve satellite data quality, utilization and data assimilation, and then improve NCEP NWP.

Thank you very much!